

## CLAIMS

1 1. A method for characterizing a contaminant in a fluid flow system, comprising the steps  
2 of:

3 (a) injecting a conservative tracer and an interactive tracer into the flow  
4 system at a first location;

5 (b) advecting the tracers along the flow system;

6 (c) extracting the tracers at a second location in the flow system;

7 (d) measuring the concentration of the extracted tracers over a period of time; and

8 (e) characterizing the contaminant from the concentrations of the tracers.

1 2. The method of claim 1 where the concentration is measured as a function of time.

1 3. The method of claim 1 wherein the characterizing includes detecting the presence of a  
2 specific contaminant of interest in the fluid flow system.

1 4. The method of claim 1 wherein the characterizing includes locating a specific  
2 contaminant of interest in the fluid flow system.

1 5. The method of claim 1 wherein the characterizing includes quantifying the amount of a  
2 specific contaminant in the flow system.

1 6. The method of claim 1 wherein the tracers are advected by a fluid that does not interact  
2 with the tracers or the contaminant.

1 7. The method of claim 1 wherein the interactive tracer is a partitioning tracer.

1 8. The method of claim 1 wherein the interactive tracer is a reactive tracer.

1 9. The method of claim 1 wherein a plurality of interactive tracers are injected.

1 10. A method for detecting the presence of a contaminant in a fluid flow system,  
2 comprising the steps of:

3 (a) injecting a conservative tracer and an interactive tracer into the flow system at a  
4 first location;

5 (b) advecting the tracers along the flow system with a fluid that does not interact  
6 with the tracers;

7 (c) extracting the tracers at a second location in the flow system;

8 (d) measuring the concentration of the extracted tracers over a period of time; and

9 (e) detecting the presence of the contaminant from a comparison of the measured  
10 concentrations.

1 11. The method of claim 10 where said concentration is measured as a function of time.

1 12. The method of claim 10 wherein the interactive tracer is a partitioning tracer.

1 13. The method of claim 10 wherein the interactive tracer is a reactive tracer.

1 14. The method of claim 10 wherein a plurality of interactive tracers are injected into the  
2 fluid flow system.

1 15. A method for determining the location of a contaminant in a fluid flow system,  
2 comprising the steps of:

3 (a) injecting a conservative tracer and a partitioning tracer into the flow system at a  
4 first location;

5 (b) advecting the tracers along the flow system at a first velocity to create an  
6 advection flow field;

- (c) extracting the tracers at a second location in the flow system;
- (d) introducing a perturbation to the advection flow field at a perturbation time by changing and then re-establishing the advection flow at a second velocity, which may be different than the first velocity, creating a unique change in the concentration of the partition tracer;
- (e) extracting the partitioning tracer as a function of time relative to the perturbation time;
- (f) measuring the concentration of the partitioning tracer as a function of the time; and
- (g) determining the location of contamination from the time of arrival of the partitioning tracer relative to the perturbation time and the advection flow velocity.

16. A method for determining the quantity of a contaminant in a fluid flow system, comprising the steps of claim 1, wherein the quantity of extracted tracer is related to the quantity of contaminant.

17. An apparatus for characterizing a contaminant in a fluid flow system, comprising:

- (a) a tracer injection system for injecting known amounts of conservative and interactive tracers into the flow system;
- (b) an advection driving system for moving the tracers along the flow system;
- (c) a tracer extraction system for removing the tracers from the fluid flow system;
- (d) a measurement system for determining the concentration of the tracers extracted from the fluid flow system; and
- (e) a processor for analyzing the concentration measurements.

18. The apparatus of claim 17, wherein the injection system includes a container with a valve holding tracers at pressure, whereby the tracers can be injected into the flow system by depressurizing the container by opening the valve on the container.

1 19. The apparatus of claim 17, wherein the driving system includes a compressed gas  
2 cylinder.

1 20. The apparatus of claim 17, wherein the measurement system includes a gas  
2 chromatograph.